CLAIMS

1. Method for producing a coating (1) on a moving substrate (2) in a vacuum chamber (10) with a residual gas by means of a sputtering apparatus (3, 7), wherein the coating (1) is formed from at least two constituents and at least a first constituent is a sputter material of the sputtering apparatus (3, 7) and at least a second constituent is a reactive component of the residual gas, characterized in that the following steps are provided:

   - With delivery of a reactive component, reactive deposition of a coating (1) on the substrate, with a given stoichiometric deficit of the second constituent in a spatial area of the sputtering apparatus (3, 7),
   - Movement of the substrate (2) with the deposited coating (1) in a spatial area of a plasma source (5) which is arranged in the vacuum chamber (10) at a given distance from the sputtering apparatus (3, 7),
   - Modification of the structure and/or stoichiometry of the coating (1) by plasma action of the plasma source (5), preferably with the input of a given amount of the reactive component to reduce an optical loss of the coating (1).

2. Method for producing a coating (1) on a moving substrate (2) in a vacuum chamber (10) with a residual gas by means of a sputtering apparatus (3, 7), the coating (1) being formed from at least two constituents and at least a first constituent is a sputter material of the sputtering apparatus (3, 7) and at least a second constituent is a reactive component of the residual gas, characterized in that the following steps are provided:

   - With delivery of a reactive component, reactive depositing of a coating (1) with a given coating thickness and an optical loss which falls below a given minimum, upon the substrate in a spatial area of the sputtering apparatus (3, 7).
   - Movement of the substrate (2) with the deposited coating (1) into a spatial area of a plasma source (5) which is arranged in the vacuum chamber (10) at a given distance from the sputtering apparatus (3, 7).
   - Modification of the structure and/or stoichiometry of the coating (1) by plasma treatment by the plasma source (5), preferably while putting in a

given amount of the reactive component, to reduce an optical loss in the coating (1).

3. Method according to claim 2, characterized in that the sputtering apparatus (3, 7) is operated at a working point dependent on sputter material and reactive gas material on a characteristic line or a characteristic map.

4. Method according to claim 2 or 3, characterized in that an optical monitoring is provided after deposit of a given coating thickness for adjustment of optical properties of the coating (1).

5. Method according to at least one of claims 2 to 4, characterized in that an optical monitoring of the coating (1) is provided after plasma treatment by the plasma source (5) to adjust optical properties of the coating (1).

6. Method according to at least one of claims 1 to 5, characterized in that an optical monitoring of the coating (1) is provided after deposit of a given coating thickness and after plasma treatment by the plasma source (5) to adjust optical properties of the coating (1).

7. Method according to at least one of claims 4 to 6, characterized in that a detection of transmission, reflection and/or loss at one or more wavelengths of the coating (1) is provided as optical monitoring.

8. Method according to at least one of claims 1 to 7, characterized in that, in accordance with a monitoring signal from an optical monitor apparatus (8), a regulation of the sputtering apparatus (3, 7) is performed.

9. Method according to at least one of claims 1 to 8, characterized in that, in accordance with a monitoring signal from an optical monitor apparatus (8), a regulation of the plasma source (5) is performed.

10. Method according to at least one of claims 4 to 9, characterized in that the optical monitoring is performed in dependence upon preset times and/or preset coating thicknesses.

11. Method according to at least one of the foregoing claims, characterized in that a content of the reactive component in the coating (1) is increased to the stoichiometric composition.

12. Method according to at least one of the foregoing claims, characterized in that the coating (1) is deposited with a preset deficit between 0 and 100% of the reactive component with respect to the reactive component of the residual gas.

13. Method according to at least one of the foregoing claims, characterized in that a partial pressure of the reactive component is regulated by a gas flow of the reactive component and/or by an electric power of the sputtering apparatus (3, 7).

14. Method according to at least one of the foregoing claims, characterized in that a sputtering cathode voltage of the sputtering apparatus (3, 7) is regulated by a gas flow of the reactive component.

15. Method according to at least one of the foregoing claims, characterized in that the quotient of a sputtering rate to a partial pressure of a reactive component is regulated by a sputtering power.

16. Method according to claim 15, characterized in that the quotient is determined from the quotient of a first line intensity and of a second line intensity, the first line intensity being a measure of the sputtering rate and the second line intensity for a partial pressure of the reactive component.

17. Method according to at least one of the foregoing claims, characterized in that the reactive component is oxygen, carbon and/or nitrogen.

18. Method according to at least one of the foregoing claims, characterized in that partial pressures of the reactive component in the area of the sputtering system (3, 7) and in the area of the plasma source (5) are established substantially independently of one another.

19. Method according to at least one of the foregoing claims, characterized in that a plasma action takes place with a plasma of a plasma source (5) which contains at least the reactive component in the plasma.

20. Method according to at least one of the foregoing claims, characterized in that the coating (1) is modified by the substoichiometric composition to a stoichiometric compound.

21. Method according to at least one of the foregoing claims, characterized in that the substrate (2) is carried at a preset velocity past the plasma source (5) and/or the sputtering apparatus (3, 7).

22. Method according to at least one of the foregoing claims, characterized in that the substrate (2) is moved past the plasma source (5) and/or the sputtering apparatus (3, 7) with a variable speed.

23. Method according to at least one of the foregoing claims, characterized in that the substrate (2) is moved repeatedly past the sputtering apparatus (3, 7) and/or past the plasma source (5).

24. Method according to at least one of the foregoing claims, characterized in that a gas flow of the reactive component is controlled or regulated according to optical properties of the coating (1).

25. Method according to at least one of the foregoing claims, characterized in that heat is applied to the substrate (2) before, during or after modification, preferably by means of radiant heating.

26. Method according to at least one of the foregoing claims, characterized in that a gas flow of the reactive component is controlled or regulated according to a deposited coating thickness and/or a duration of the modification and/or a number of passages past the plasma source (5).

27. Method according to at least one of the foregoing claims, characterized in that a preferably magnetron-supported cathode sputtering source is provided.

28. Method according to at least one of the foregoing claims, characterized in that the sputtering apparatus (3, 7) is operated with an alternating electrical field.

29. Method for preparing a multilayer coating with at least one reactively operated coating apparatus (3) and at least one reaction apparatus (5) in a vacuum chamber

(10), wherein on at least one substrate moving relative to the coating apparatus (3) or the reaction apparatus (5) a depositing of a second layer with the reactive component takes place, and an alteration of the structure and/or stoichiometry of at least one layer is performed by means of the reaction apparatus (5), characterized in that, to reduce optical loss in the multilayer coating below a predetermined value, a build-up of an interface is performed in a region adjoining the first layer, with a thickness d_1 and a value of a deficit of the reactive component DEF smaller than a value DEF_1.

30. Method according to claim 29, characterized in that values of a momentary thickness d(t) of the second layer are obtained, preferably during the deposition of the second layer, and as soon as d(t) is greater than d_1 the deposition of the second layer is performed with a value of the deficit of the reactive component DEF greater than DEF_1.

31. Method according to claim 29 or 30, characterized in that at least one of the layers is made after at least one of the processes according to claims 1 to 28.

32. Method according to any one of claims 29 to 31, characterized in that the first layer is high-refracting and the second layer low-refracting, or that the first layer is low-refracting and the second layer high-refracting, the high-refracting layer consisting, for example, of N_2O_5, Ta_2O_5, and the low-refracting layer of SiO_2.

33. Method according to at least one of claims 29 to 32, characterized in that Nb_2O_5 is provided as the high-refracting layer and SiO_2 as the low-refracting layer and thickness d_1 of the interface layer has a value of 2.5 nm, 2.6 nm, 2.7 nm ... 3.6 nm ... 10.0 nm, and the deficit of the reactive component DEF_1 a value of less than 0.5, 04., 0.3, 0.2, preferably less than 0.1.

34. Method according to at lest one of the foregoing claims, characterized in that, for a given thickness d_1 of the interface, as the rate of deposition increases, a diminishing value of the deficit of the reactive component DEF is chosen.

35. Method according to at least one of claims 29 to 34, characterized in that the multilayer coating has a number of interfaces between high-refracting and low-refracting coatings N_1 greater than 3, preferably greater than 20, especially preferably greater than 80.

36. Method according to at least one of claims 29 to 35, characterized in that the coating apparatus (3) is a magnetron source system operated preferably at medium frequency, preferably with two magnetron systems lying side by side, and/or the reactive apparatus (5) is a plasma source operating preferably in an RF range.

37. Method according to at least one of claims 29 to 36, characterized in that the changing of the texture and/or stoichiometry of the coatings is performed in each case after the deposition of a coating with a given layer density.

38. Apparatus for producing a coating (1) on a substrate (2) by means of a sputtering system (3, 7) in a vacuum chamber (10) with a residual gas, the coating (1) being formed from at least two constituents and at least a first constituent is a sputter material of the sputtering system (3, 7) and at least a second constituent is a reactive component of the residual gas, characterized in that

- Means for the reactive deposit of a coating (1) on the substrate (2) with the feeding of a reactive component with a predetermined stoichiometric deficit of the reactive component in the vicinity of the sputtering apparatus (3, 7).
- Means for the moving of the substrate (2) with the deposited coating (1) in the vicinity of a plasma source (5) which is arranged at a given distance from the sputtering apparatus (3, 7) in the vacuum chamber.
- Means for modifying the texture and/or stoichiometry of the coating (1) by plasma treatment with the plasma source (5), preferably while supplying a given amount of the reactive component, to reduce an optical loss in the coating (1).

are provided.

39. Apparatus for producing a coating (1) on a substrate (2) by means of a sputtering system (3, 7) in a vacuum chamber (10) with a residual gas, the coating (1) being formed of at least two components and at least a first constituent is a sputter

material from the sputtering system (3, 7) and at least a second constituent is a reactive component of the residual gas, characterized in that

- Means for the reactive deposition of a coating (1) on the substrate (2) in the vicinity of the sputtering system (3, 7) while supplying a reactive component with an optical loss falling below a minimum at a given coating thickness,
- Means for moving the substrate (2) with the deposited coating (1) in the vicinity of the plasma source (5) which is arranged in the vacuum chamber at a given distance from the sputtering system,
- Means for modifying the structure and/or stoichiometry of the coating (1) by plasma treatment by the plasma source (5), preferably while supplying a given amount of the reactive component, to reduce an optical loss in the coating (1)

are provided.

40. Apparatus according to claim 38 or 39, characterized in that, in the vicinity of the sputtering apparatus (3, 7) and in the vicinity of the plasma source (5) a gas supply and/or a pump unit are arranged which have pass-throughs for at least one substrate (2).

41. Apparatus according to claim 39 or 40, characterized in that the substrate (2) is arranged on a turntable (6) spaced away rom the sputtering system (3, 7) and from the plasma source (5).

42. Apparatus according to at least one of claims 39 to 41, characterized in that several substrates (2, 2ÿ) are arranged on the turntable (6).

43. Apparatus according to at least one of claims 39 to 42, characterized in that the sputtering apparatus (3, 7) and the plasma source (5) are arranged to correspond to the turntable (6) to some extent in the direction of the circumference of the turntable (6).

44. Apparatus according to at least one of claims 39 to 43, characterized in that at least two sputtering apparatus (3, 7) are disposed preferentially diametrically opposite one another.

45. Apparatus according to claim 44, characterized in that at least one plasma source (5) is arranged spatially between the sputtering apparatus (3, 7).

46. Apparatus according to at least one of claims 39 to 45, characterized in that spatially between the sputtering apparatus (3, 7), an optically measuring device is arranged for measuring an optical transmission, reflection and/or losses of a coating (1) deposited on the substrate (2).

47. Apparatus according to at least one of claims 39 to 46, characterized in that at least one optical measuring apparatus is disposed spatially between the sputtering apparatus (3, 7).

48. Apparatus according to claim 46 or 47, characterized in that the optical measuring apparatus is a one-wavelngth or multiple wavelength photometer and/or ellipsometer.

49. Apparatus according to at least one of claims 39 to 48, characterized in that a heating system is arranged at least in an area of the vacuum chamber (100) for heating the substrate.

50. Apparatus according to at least one of claims 39 to 49, characterized in that a magnetron-supported cathode sputtering source is provided as sputtering system (3, 7), preferably with two magnetron systems lying side by side.

51. Apparatus according to at least one of claims 39 to 50, characterized in that the sputtering apparatus (3, 7) is operated with an electrical alternating field, preferably in a high-frequency, medium-frequency or pulsed DC range.

52. Apparatus according to at least one of claims 39 to 51, characterized in that the plasma source (5) is an ECWR source, a Hall End plasma source, a hot cathode DC plasma source, a high-frequency plasma source, a medium-frequency or pulsed DC plasma source.

53. Apparatus for producing a multilayer coating with at least one reactively operated coating apparatus (3), especially a sputtering apparatus and at least one reaction apparatus (5), especially a plasma source in a vacuum chamber (10), wherein a

deposit of a second coating with at least one reactive component can take place on at least one substrate moving relative to the coating apparatus (3) and the reaction apparatus (5), and a change of the texture and/or stoichiometry of at least one coating is made by means of the reaction apparatus (5), characterized in that, for the reduction of an optical loss from the multilayer coating below a given value, a control system for controlling the coating apparatus and reaction apparatus is provided by means of which, in a region of the second layer adjoining the first layer, a formation of an interface with a thickness d_1 and a value of a deficit of the reactive component DEF lower than a value DEF_1 can take place.

54. Multilayer coating produced by the method of at least one of claims 29 to 37.